



UCSB



7 TeV “AFB” analyses status (TOP-13-003 and TOP-12-010)

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9th July 2013



- ▶ We measure the top charge asymmetry, polarization and variables related to the spin correlation in the dilepton final state
- ▶ Top and lepton charge asymmetries: $A_{lepC} = \frac{N(|\eta_{l+}| > |\eta_{l-}|) - N(|\eta_{l+}| < |\eta_{l-}|)}{N(|\eta_{l+}| > |\eta_{l-}|) + N(|\eta_{l+}| < |\eta_{l-}|)}$
(and similarly for A_C)
- ▶ Top polarization $P_n = \frac{N(\cos(\theta_l^+) > 0) - N(\cos(\theta_l^+) < 0)}{N(\cos(\theta_l^+) > 0) + N(\cos(\theta_l^+) < 0)}$
 - ▶ measured in the helicity basis
- ▶ Two spin correlation variables:
 - ▶ Direct (from the correlation between the + and - lepton directions)
 - ▶ $A_{c1c2} = \frac{N(\cos(\theta_l^+) \times \cos(\theta_l^-) > 0) - N(\cos(\theta_l^+) \times \cos(\theta_l^-) < 0)}{N(\cos(\theta_l^+) \times \cos(\theta_l^-) > 0) + N(\cos(\theta_l^+) \times \cos(\theta_l^-) < 0)}$
 - ▶ Indirect (lepton azimuthal asymmetry discriminates between correlated and uncorrelated $t\bar{t}$) - note, this is a purely leptonic variable (lab frame)
 - ▶ $A_{\Delta\phi} = \frac{N(\Delta\phi_{l+l-} < \pi/2) - N(\Delta\phi_{l+l-} > \pi/2)}{N(\Delta\phi_{l+l-} < \pi/2) + N(\Delta\phi_{l+l-} > \pi/2)}$

- ▶ Data driven background predictions complete
- ▶ Systematics complete except for PDF (which is partially complete and seems to be small)
 - ▶ when this is done the final results for the papers will be complete
- ▶ We're currently updating the paper drafts (TOP-13-003 and TOP-12-010)

- ▶ We use raw MC to estimate the backgrounds
- ▶ We make cross-checks for the DY and fake components using data-driven methods, and find reasonable agreement
 - ▶ DY estimate (after event selection): 45.6 ± 6.8 (stat+syst) events
 - ▶ consistent with MC prediction of 39.8 ± 4.9 events
 - ▶ Fake estimate (after event selection): 237^{+294}_{-237} (stat+syst) events
 - ▶ consistent with MC prediction 150 ± 8 events
- ▶ We then assign appropriate background normalization systematics (100% for DY and fake, 50% for other backgrounds)
 - ▶ we can afford to be very conservative with the background systematic, because it is negligible for all our measurements

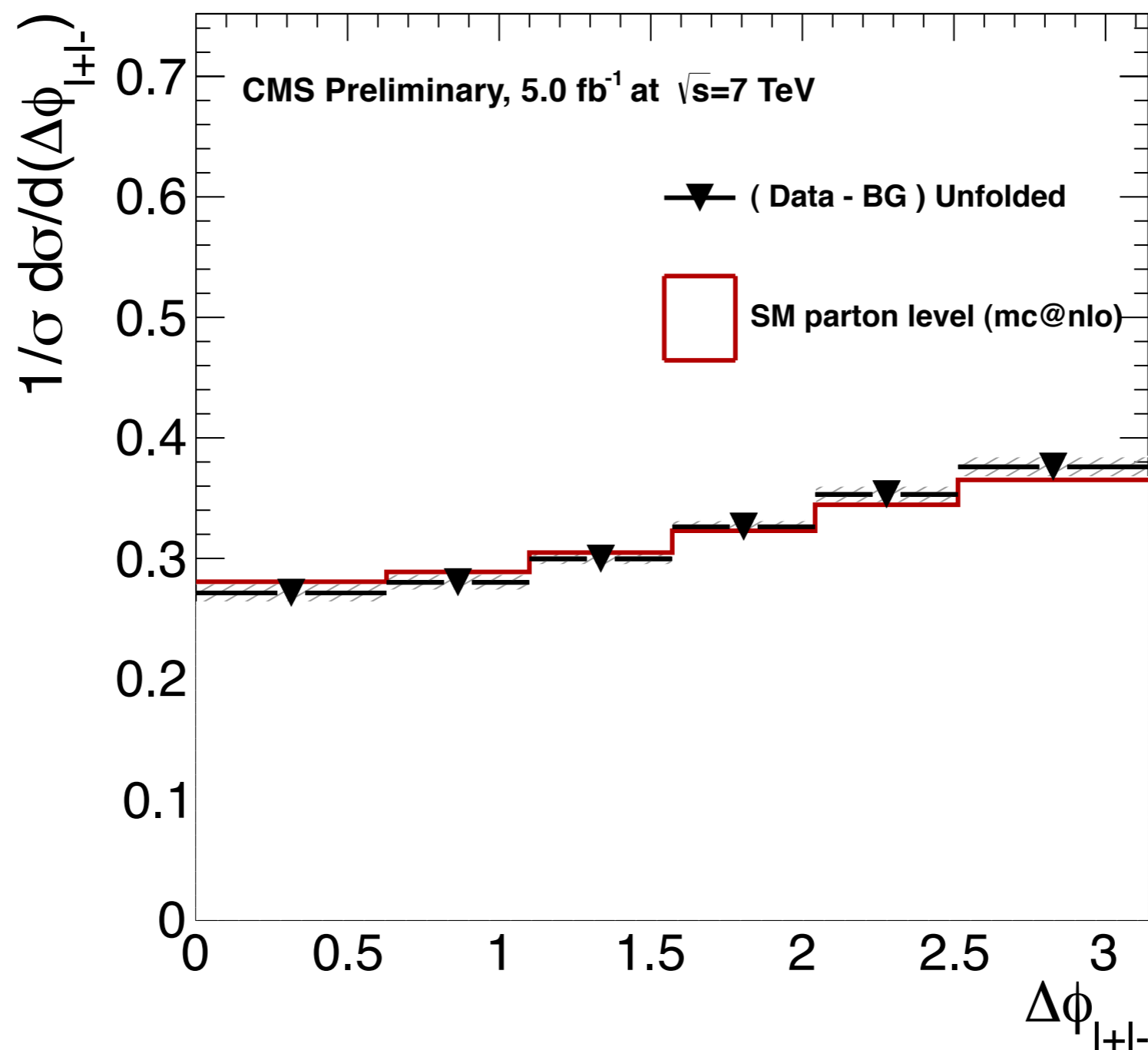
- Inclusive asymmetry results (in blue) and breakdown of systematics
- PDF systematics are extrapolated (not all jobs complete yet)

	Asym value	stat uncert (inc unfolding syst)	syst uncert without pt rewt	syst uncert incl. 50% pt rewt	syst uncert incl. 100% pt rewt	JER	JES	b-tag SF	Trigger SF	lepton energy scale	PU	mass	scale	tau	top pT reweigh ting	PDF	backgro und
lep charge asymmetry	0.009	0.014	0.006	0.006	0.006	0.000	0.001	0.000	0.000	0.000	0.001	0.002	0.005	0.000	0.000	0.000	0.001
lep azimuthal asymmetry (delta phi)	0.113	0.012	0.006	0.009	0.014	0.000	0.003	0.000	0.000	0.001	0.002	0.003	0.001	0.001	0.012	0.003	0.003
polarization (plus)	-0.009	0.025	0.039	0.039	0.039	0.000	0.012	0.001	0.000	0.001	0.002	0.035	0.007	0.001	0.007	0.009	0.004
polarization (minus)	0.019	0.023	0.024	0.024	0.025	0.000	0.007	0.001	0.000	0.001	0.005	0.019	0.001	0.001	0.008	0.008	0.007
polarization (combined)	0.005	0.019	0.031	0.031	0.032	0.000	0.009	0.001	0.000	0.001	0.004	0.027	0.004	0.001	0.008	0.008	0.006
top spin correlation	-0.020	0.035	0.021	0.021	0.023	0.000	0.011	0.000	0.000	0.001	0.002	0.014	0.009	0.001	0.010	0.006	0.001
top charge asymmetry	-0.011	0.023	0.005	0.005	0.006	0.000	0.003	0.000	0.000	0.000	0.000	0.003	0.003	0.000	0.001	0.000	0.000

- Also have all these systematics for the 2D unfolded results, as well as bin-by-bin (see plots on next slides)

► Spin correlation ($\Delta\phi$)

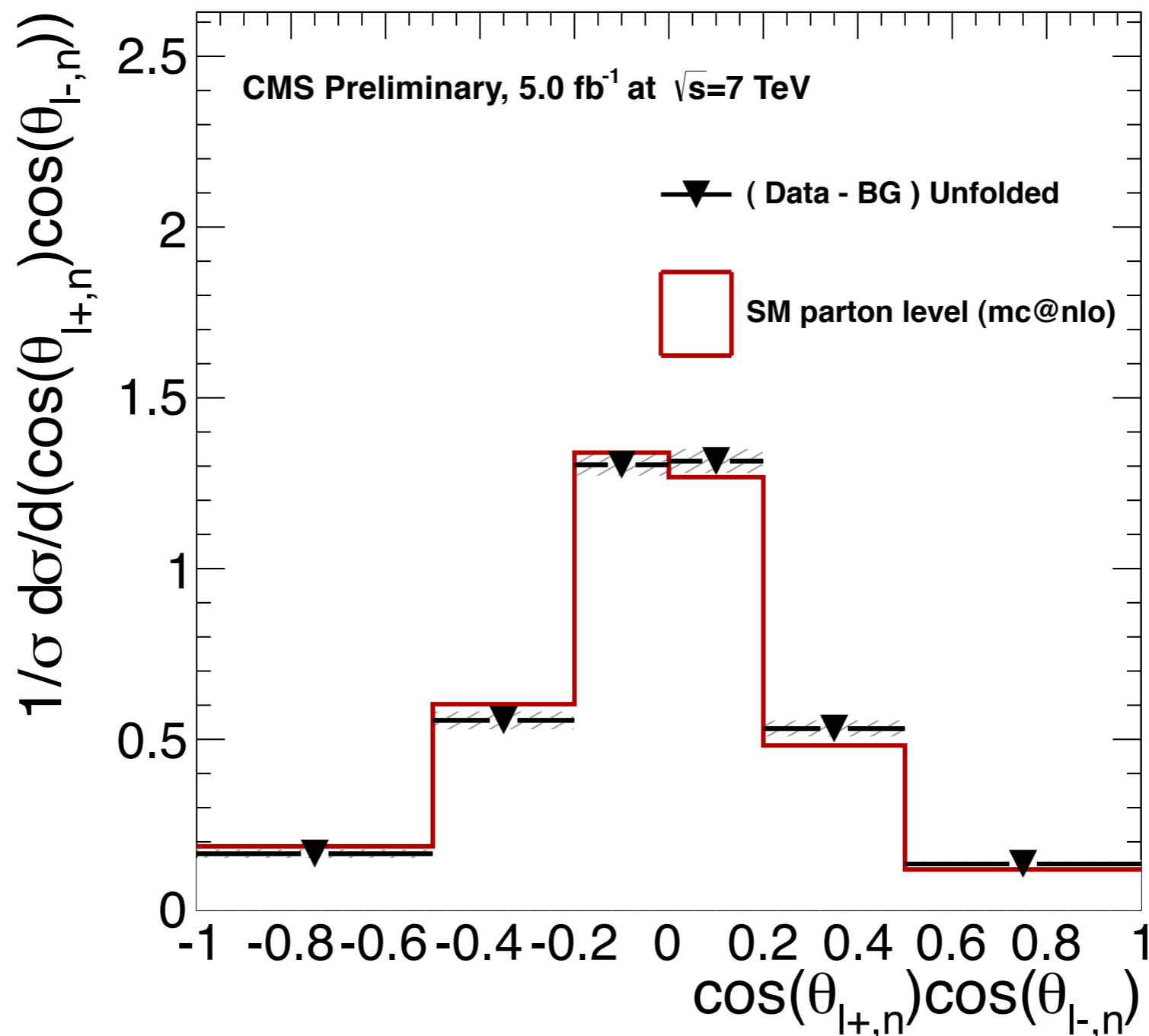
- error bars show stat uncertainty, shaded area shows systematic uncertainty



TOP-13-003

► Spin correlation (direct)

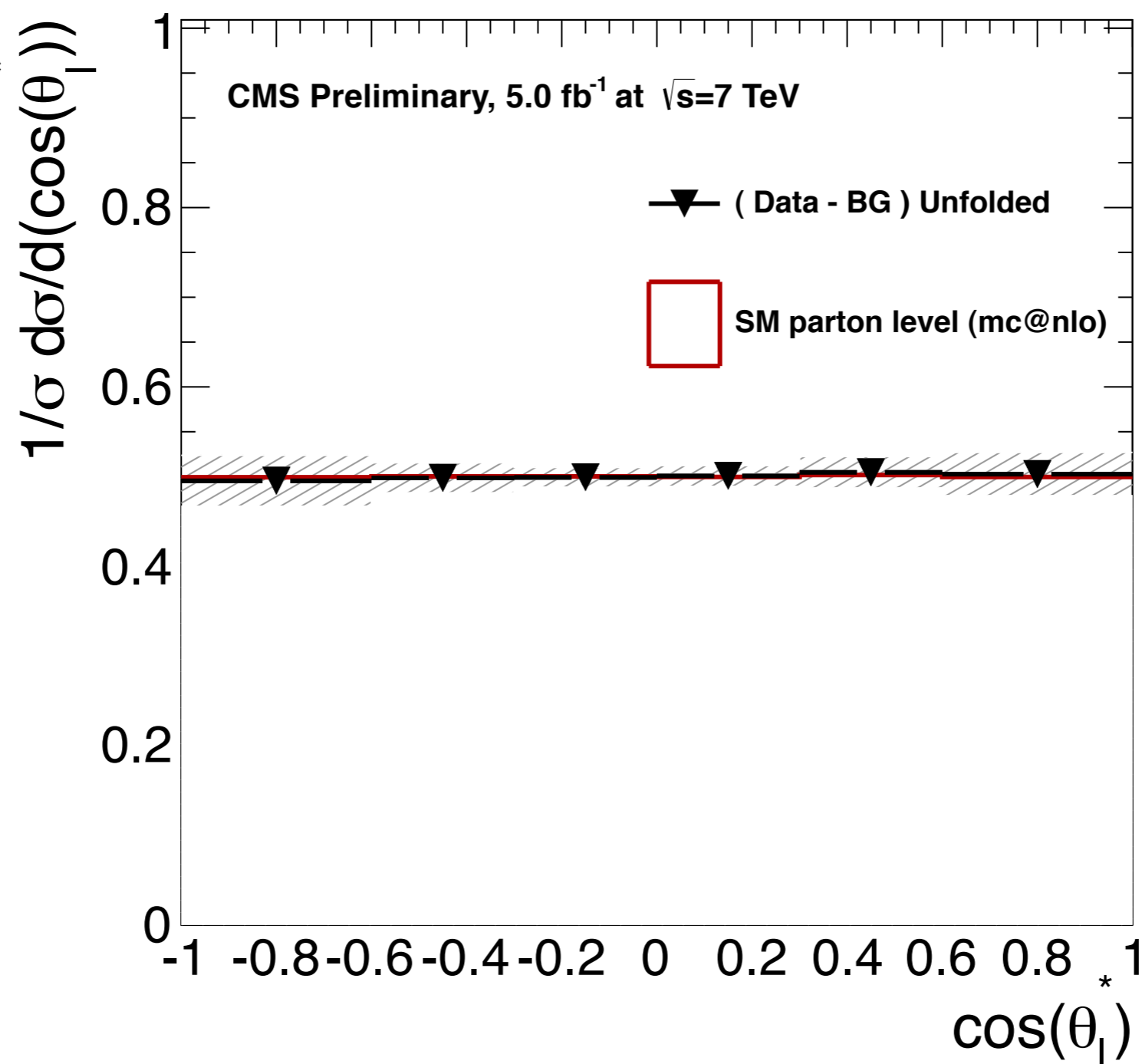
- error bars show stat uncertainty, shaded area shows systematic uncertainty



TOP-13-003

Polarisation

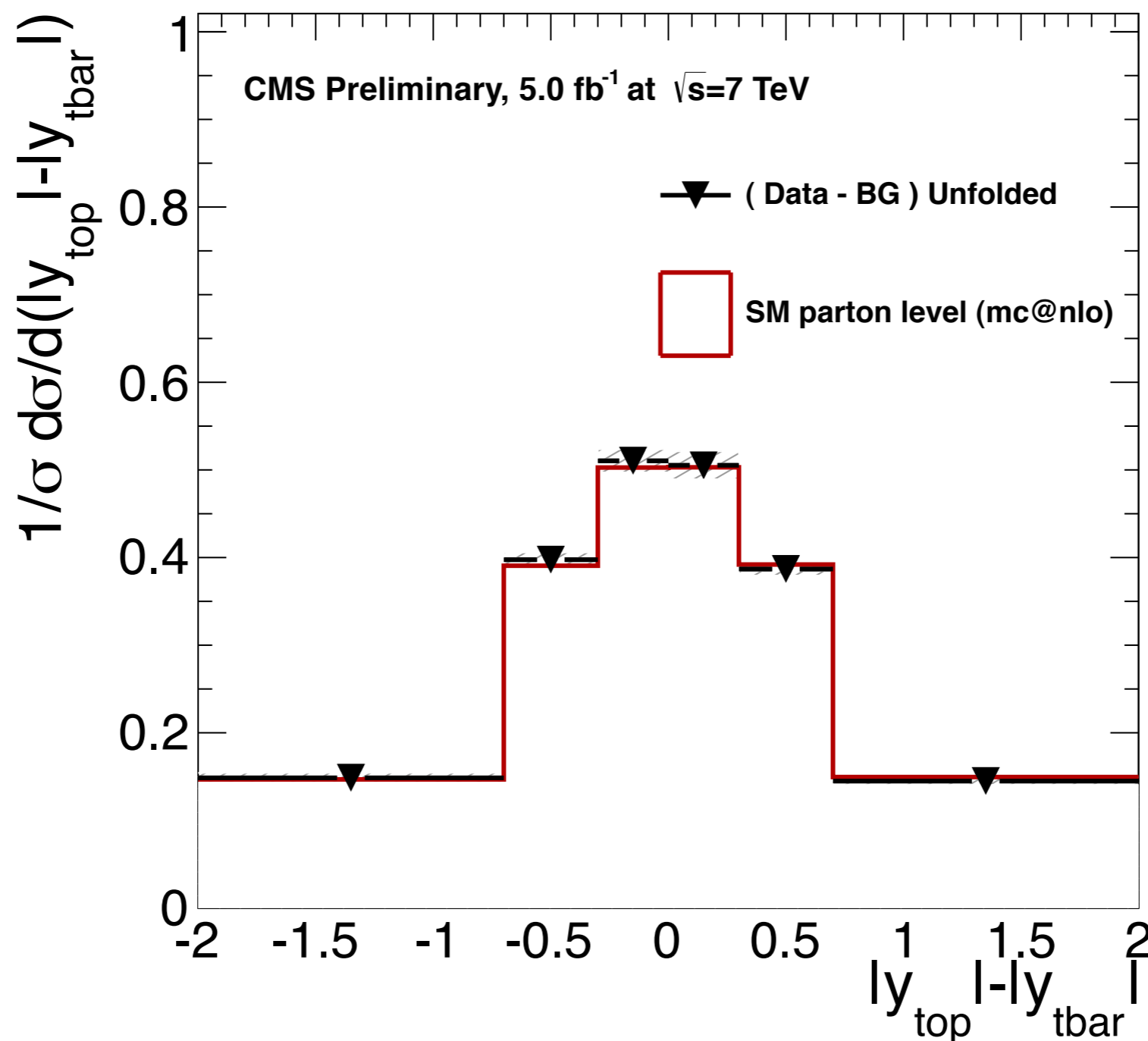
- error bars show stat uncertainty, shaded area shows systematic uncertainty



TOP-13-003

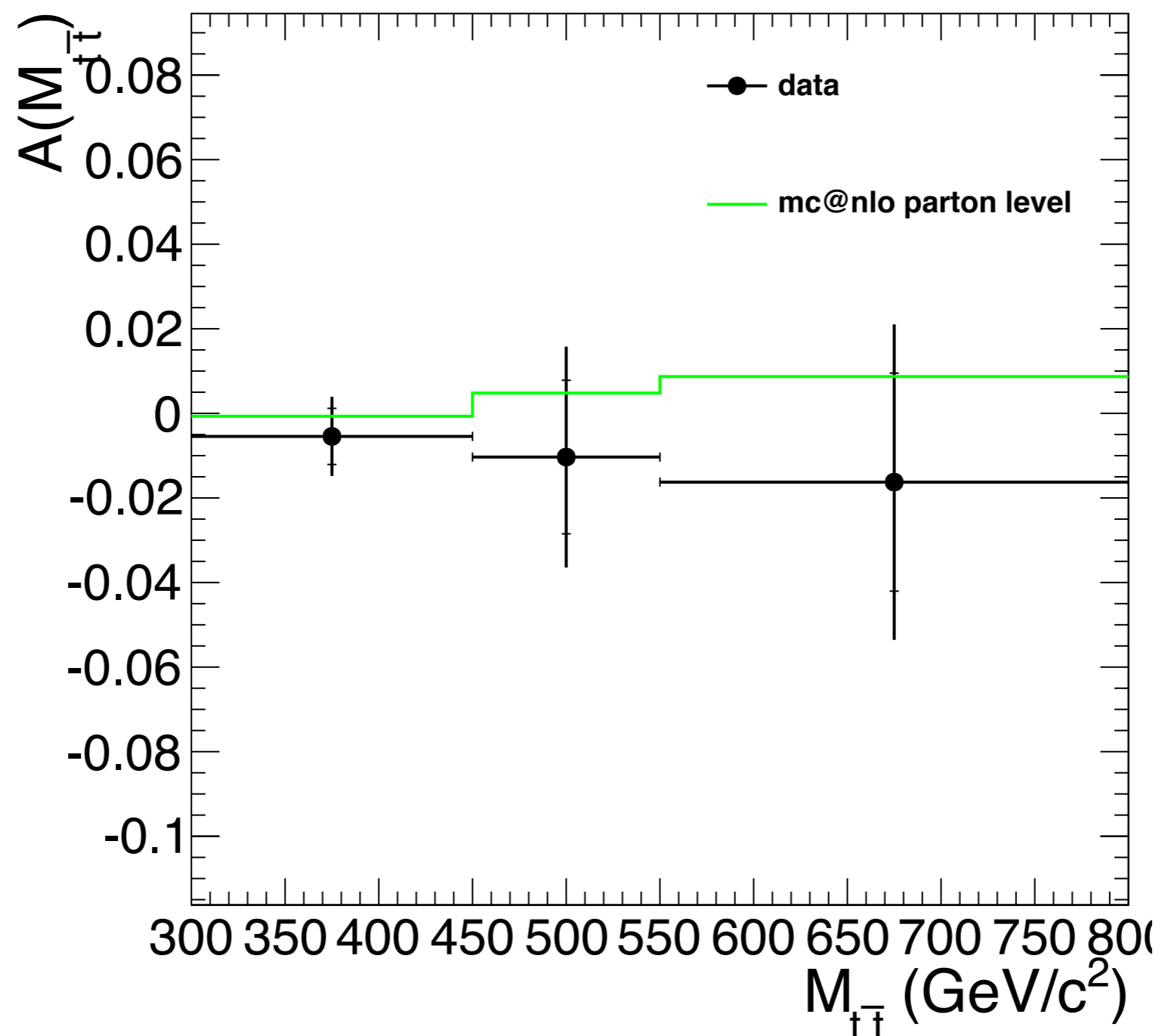
Top charge asymmetry

- error bars show stat uncertainty, shaded area shows systematic uncertainty



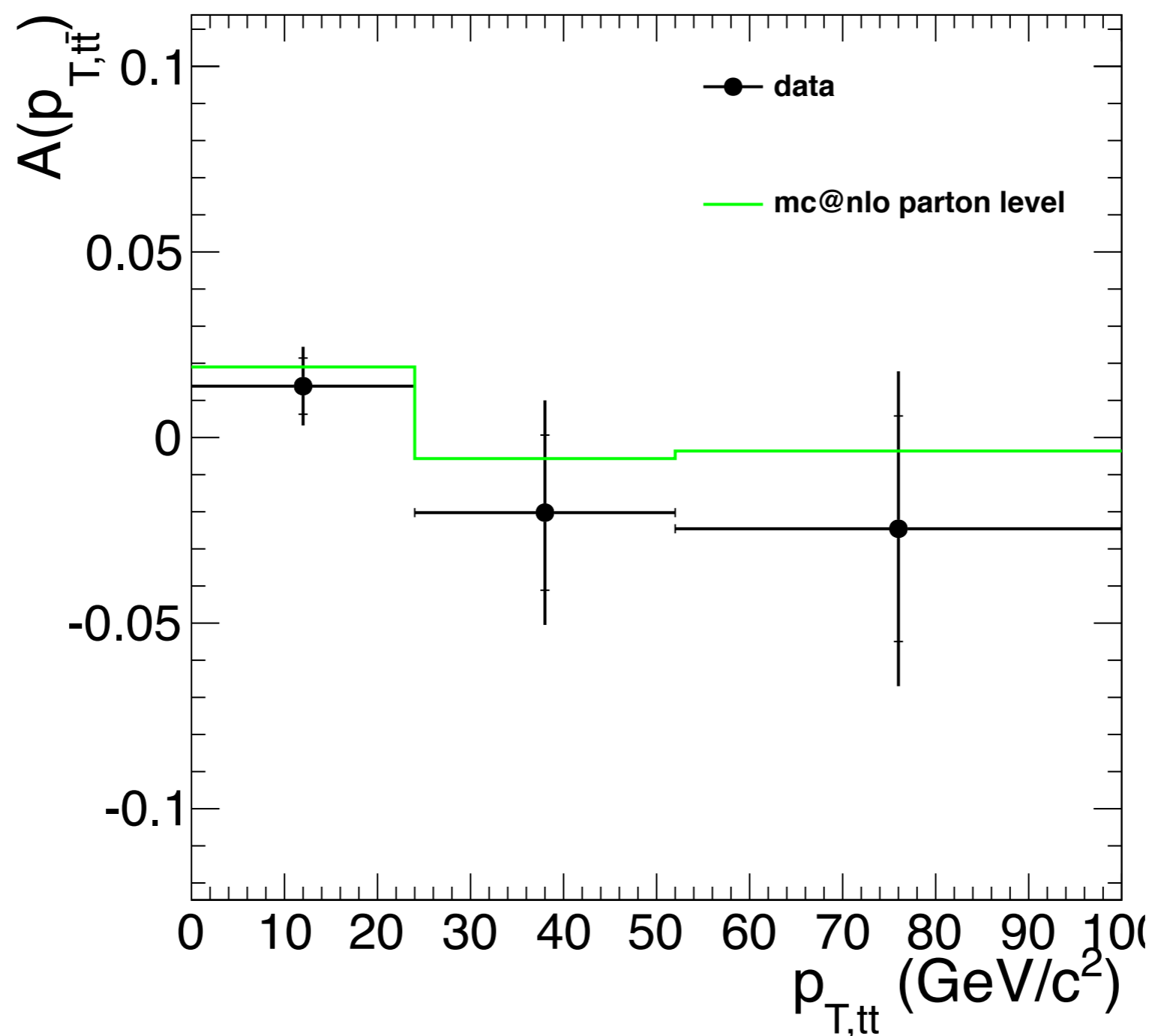
TOP-12-010

- ▶ Top charge asymmetry as a function of $M_{t\bar{t}}$
 - ▶ error bars include stat+syst, small horizontal bars show stat-only component



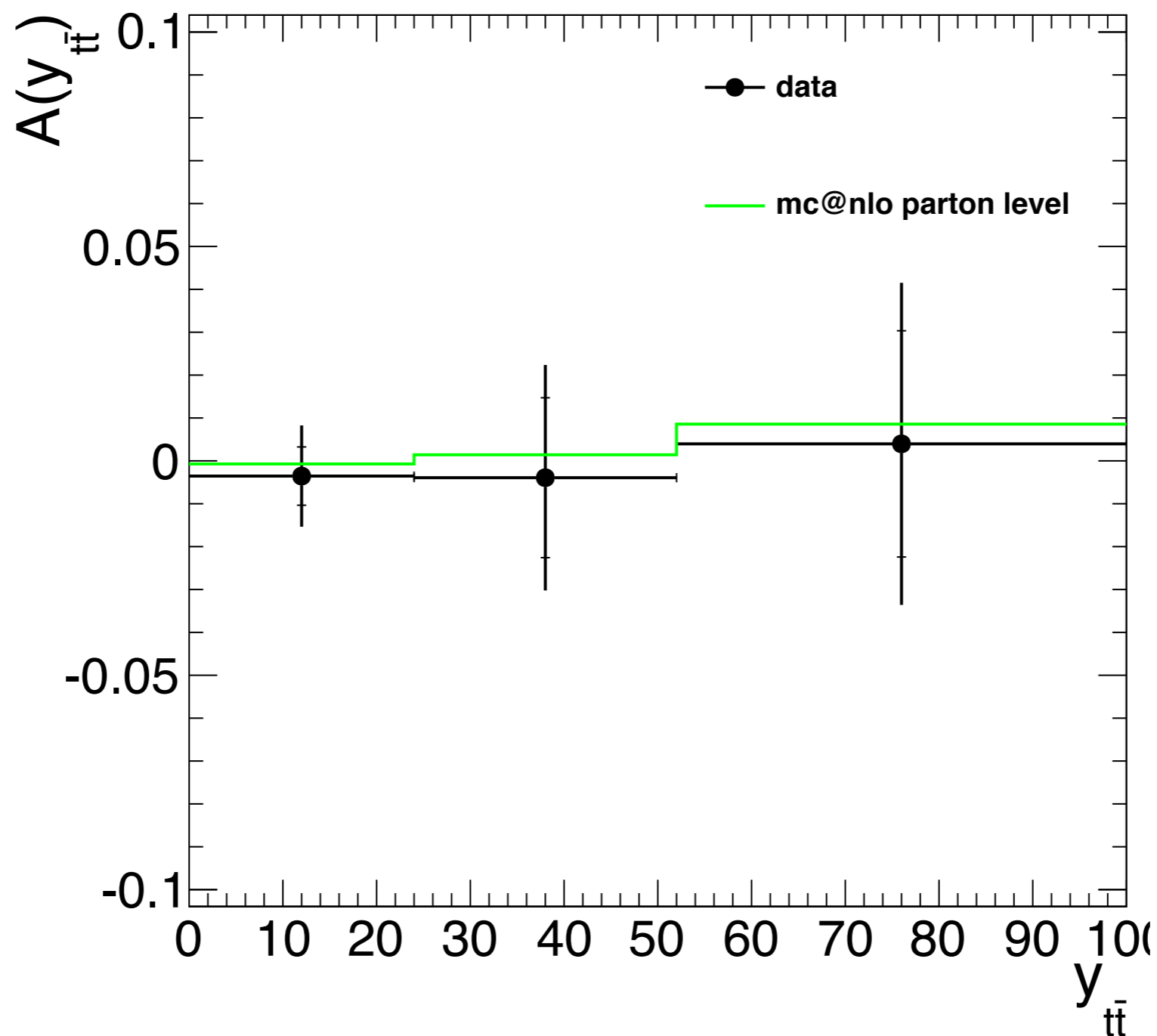
TOP-12-010

- ▶ Top charge asymmetry as a function of $p_{T,tt\bar{t}}$
 - ▶ error bars include stat+syst, small horizontal bars show stat-only component



TOP-12-010

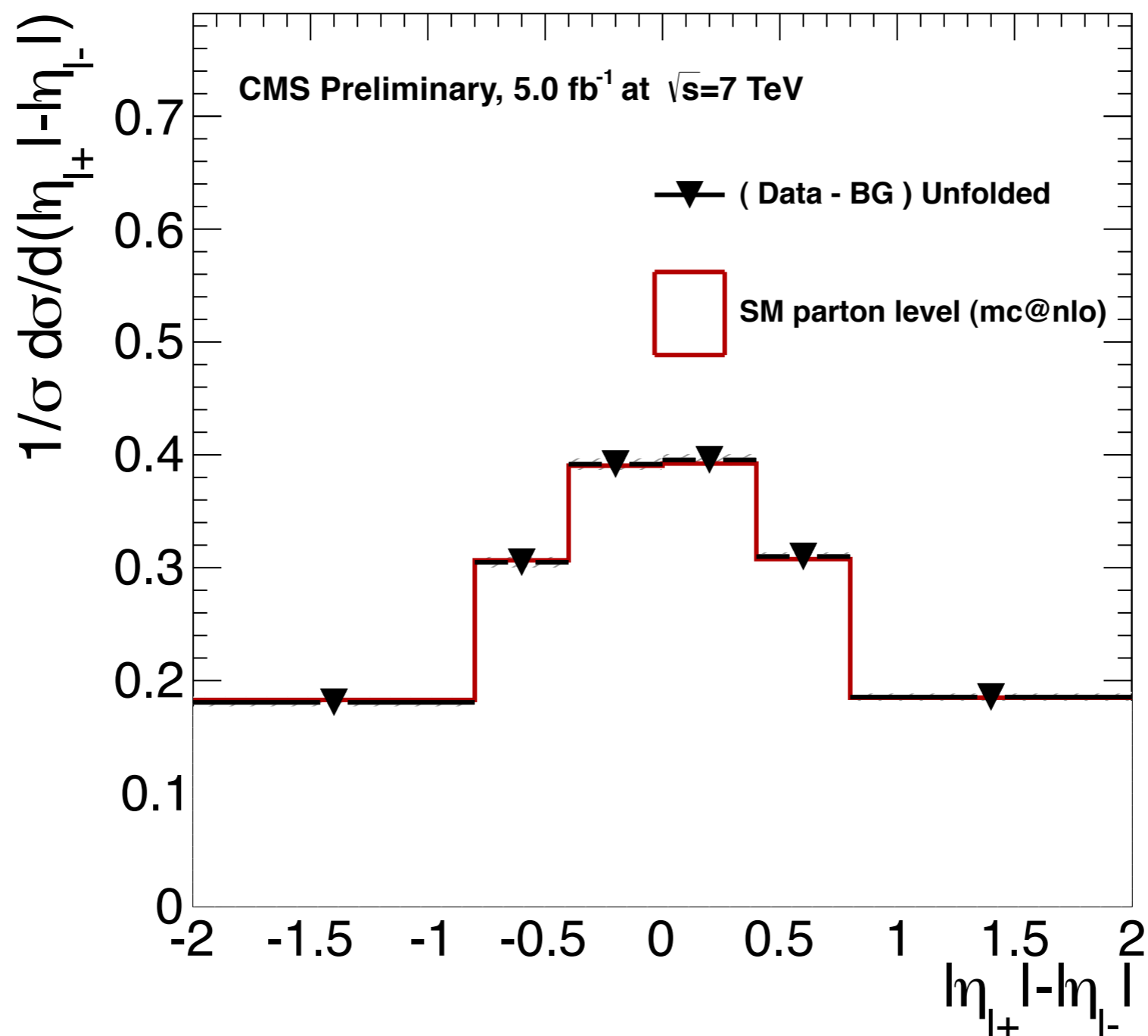
- ▶ Top charge asymmetry as a function of $y_{t\bar{t}}$
 - ▶ error bars include stat+syst, small horizontal bars show stat-only component



TOP-12-010

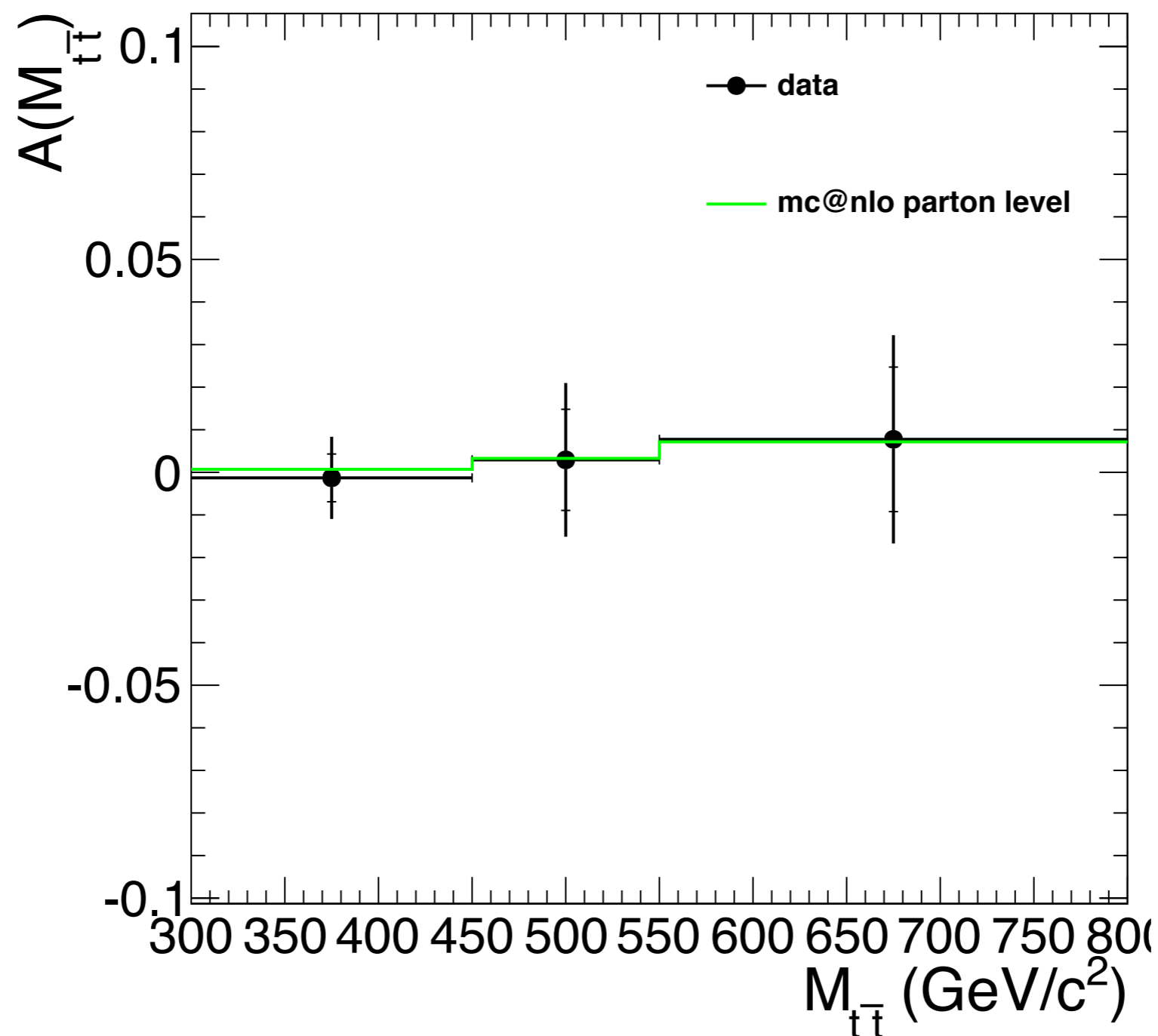
► Lepton charge asymmetry

- error bars show stat uncertainty, shaded area shows systematic uncertainty



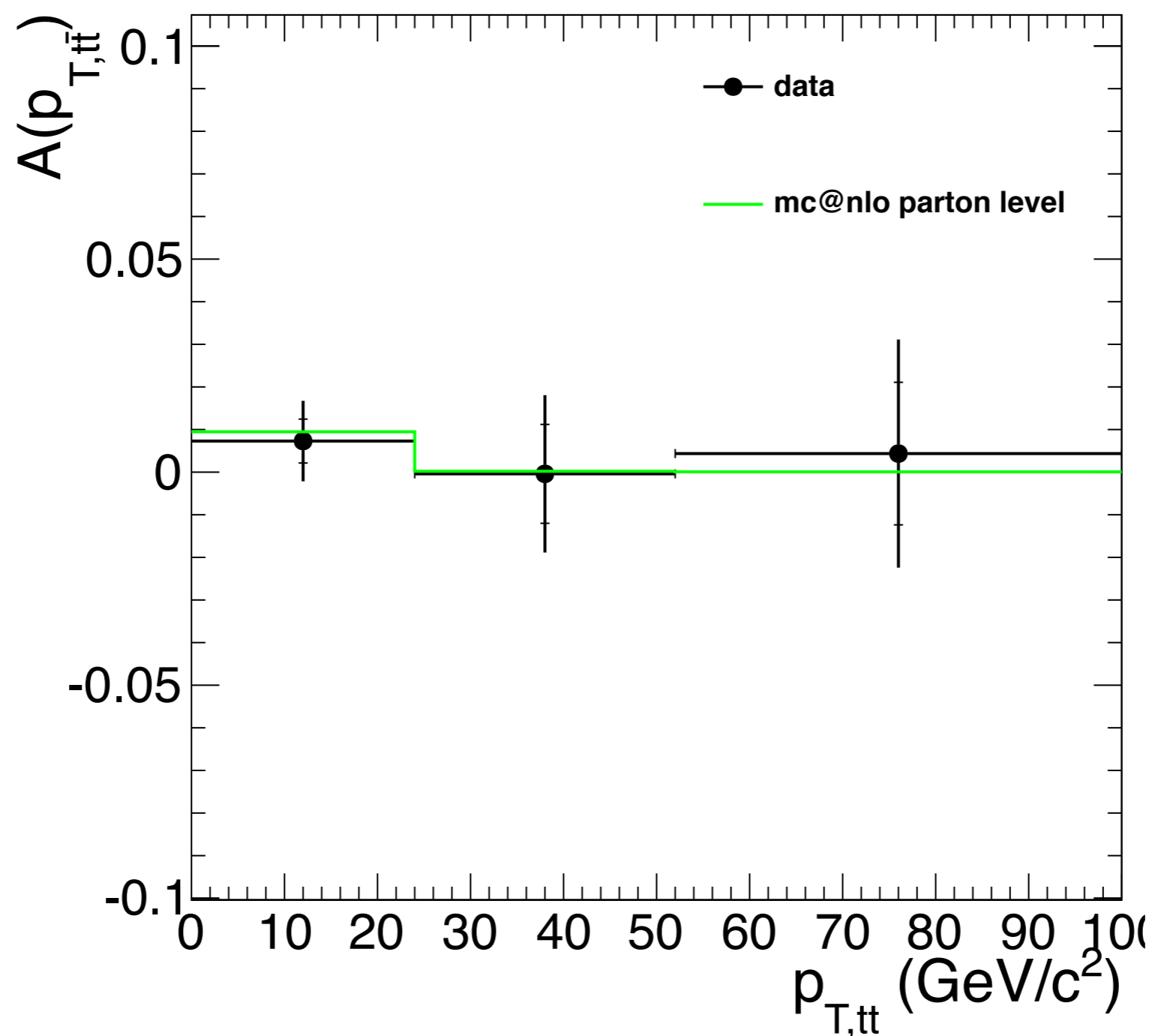
TOP-12-010

- ▶ Lepton charge asymmetry as a function of $M_{t\bar{t}}$
 - ▶ error bars include stat+syst, small horizontal bars show stat-only component



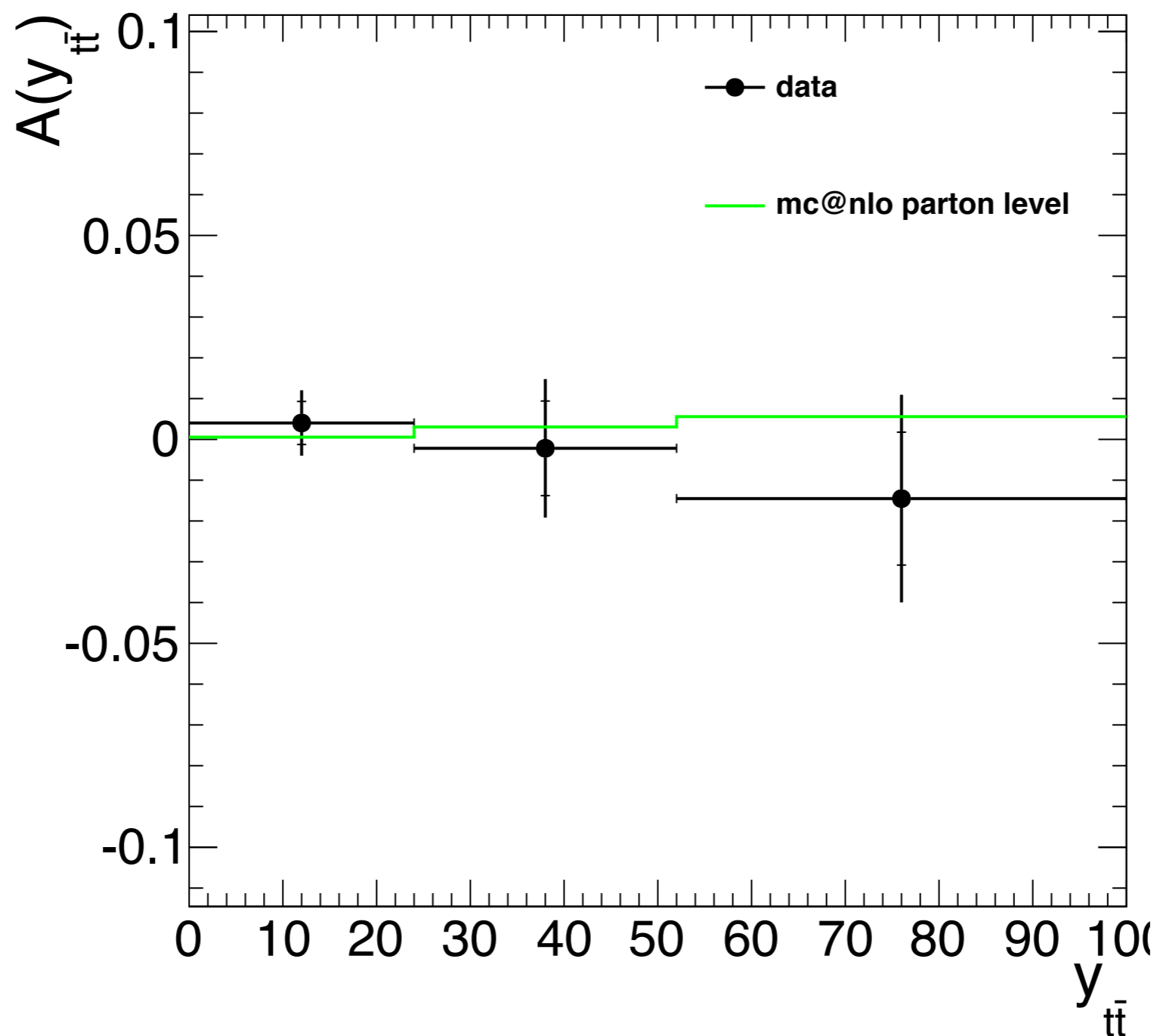
TOP-12-010

- ▶ Lepton charge asymmetry as a function of $p_{T,tt\bar{t}}$
 - ▶ error bars include stat+syst, small horizontal bars show stat-only component



TOP-12-010

- ▶ Lepton charge asymmetry as a function of $y_{t\bar{t}}$
 - ▶ error bars include stat+syst, small horizontal bars show stat-only component



TOP-12-010



Backup



- ▶ **Selection designed to reject events other than $t\bar{t}$**
- ▶ Dilepton triggers: dimuon, dielectron or electron-muon
- ▶ 2 opposite sign isolated leptons: $p_T > 20 \text{ GeV}$, $|\eta| < 2.5$ (2.4) for e (μ)
- ▶ ≥ 2 pf jets with $p_T > 30 \text{ GeV}$, $|\eta| < 2.5$
 - ▶ loose pfjet ID (L1FastL2L3 corrected)
 - ▶ $\Delta R > 0.4$ from all leptons passing analysis selection
 - ▶ ≥ 1 b tags: CSVM
- ▶ $\text{MET} > 40 \text{ GeV}$ (ee and $\mu\mu$ channels only)
- ▶ Z veto: $76 < m_{ll} < 106 \text{ GeV}$ veto (for SF leptons)
- ▶ $m_{ll} > 20 \text{ GeV}$ to veto low mass resonances (SF leptons)



Event Samples

- TTJets_TuneZ2_7TeV-madgraph-tauola_Summer11-PU_S4_START42_V11-v1 , 154 pb
- TTTo2L2Nu2B_7TeV-powheg-pythia6_Summer11-PU_S4_START42_V11-v1 , 16.2 pb
- /TT_TuneZ2_7TeV-mcatnlo/Fall111-PU_S6_START42_V14B-v1/AODSIM , 154 pb
- T_TuneZ2_tW-channel_7TeV-madgraph_Summer11-PU_S4_START42_V11-v1 , 7.87 pb
- T_TuneZ2_t-channel_7TeV-madgraph_Summer11-PU_S4_START42_V11-v1 , 41.92 pb
- T_TuneZ2_s-channel_7TeV-madgraph_Summer11-PU_S4_START42_V11-v1 , 3.19 pb
- Tbar_TuneZ2_tW-channel_7TeV-madgraph_Summer11-PU_S4_START42_V11-v1 , 7.87 pb
- Tbar_TuneZ2_t-channel_7TeV-madgraph_Summer11-PU_S4_START42_V11-v1 , 22.65 pb
- Tbar_TuneZ2_s-channel_7TeV-madgraph_Summer11-PU_S4_START42_V11-v1 , 1.44 pb
- WJetsToLNu_TuneZ2_7TeV-madgraph-tauola_Summer11-PU_S4_START42_V11-v1 , 31314 pb
- DYJetsToLL_TuneD6T_M-50_7TeV-madgraph-tauola_Summer11-PU_S4_START42_V11-v1 , 3048 pb
- DYToEE_M-20_CT10_TuneZ2_7TeV-powheg-pythia_Summer11-PU_S4_START42_V11-v1 , 1666 pb
- DYToMuMu_M-20_CT10_TuneZ2_7TeV-powheg-pythia_Summer11-PU_S4_START42_V11-v1 , 1666 pb
- DYToTauTau_M-20_CT10_TuneZ2_7TeV-powheg-pythia-tauola_Summer11-PU_S4_START42_V11-v1 , 1666 pb
- DYToEE_M-10To20_TuneZ2_7TeV-pythia6_Summer11-PU_S4_START42_V11-v1 , 3319.61 pb
- DYToMuMu_M-10To20_TuneZ2_7TeV-pythia6_Summer11-PU_S4_START42_V11-v1 , 3319.61 pb

- DYToTauTau_M-10To20_CT10_TuneZ2_7TeV-powheg-pythia-tauola_Summer11-PU_S4_START42_V11-v2 , 3319.61 pb
- WWJetsTo2L2Nu_TuneZ2_7TeV-madgraph-tauola_ummer11-PU_S4_START42_V11-v1, 4.783 pb
- WZJetsTo2L2Q_TuneZ2_7TeV-madgraph-tauola_Summer11-PU_S4_START42_V11-v1, 1.786 pb
- WZJetsTo3LNu_TuneZ2_7TeV-madgraph-tauola_Summer11-PU_S4_START42_V11-v1, 0.856 pb
- ZZJetsTo2L2Nu_TuneZ2_7TeV-madgraph-tauola_Summer11-PU_S4_START42_V11-v1, 0.30 pb
- ZZJetsTo2L2Q_TuneZ2_7TeV-madgraph-tauola_Summer11-PU_S4_START42_V11-v1, 1.0 pb
- ZZJetsTo4L_TuneZ2_7TeV-madgraph-tauola/_Summer11-PU_S4_START42_V11-v1, 0.076 pb
- /Wprime_SM_400_Madgraph_v2/yanjuntu-Wprime_SM_400_Madgraph_v2-f3d3f52ad6235ba5a3ccb05162c152b9/USER
- /Wprime_ttbar_600_Madgraph/yanjuntu-Wprime_ttbar_600_Madgraph-f3d3f52ad6235ba5a3ccb05162c152b9/USER
- AxigluonR_2TeV_ttbar_MadGraph_sergo-AxigluonR_2TeV_ttbar_MadGraph



Data: May10th rereco + Prompt v4 +
Aug05th rereco + Prompt v6 + 2011B
Data (5.0 fb⁻¹)

- Double Electron
 - HLT_Ele17_CaloIdL_CaloIsoVL_Ele8_CaloIdL_CaloIsoVL
 - HLT_Ele17_CaloIdT_TrkIdVL_CaloIsoVL_TrkIsoVL_Ele8_CaloIdT_TrkIdVL_CaloIsoVL_TrkIsoVL
 - HLT_Ele17_CaloIdT_CaloIsoVL_TrkIdVL_TrkIsoVL_Ele8_CaloIdT_CaloIsoVL_TrkIdVL_TrkIsoVL
- Double Muon
 - HLT_DoubleMu7
 - HLT_Mu13_Mu7
 - HLT_Mu13_Mu8
 - HLT_Mu17_Mu8
- Electron Muon
 - HLT_Mu17_Ele8_CaloIdL
 - HLT_Mu8_Ele17_CaloIdL
 - HLT_Mu17_Ele8_CaloIdT_CaloIsoVL
 - HLT_Mu8_Ele17_CaloIdT_CaloIsoVL

For the high p_T dilepton triggers, the efficiencies listed in Table 1, Table 2, Table 3 and Table 4 are applied to ee , $\mu\mu$ and $e\mu$ Monte Carlo Events. Details of the measurement of the trigger efficiencies are described in [12].

Table 1: The efficiency of the leading leg requirement for the double electron trigger, averaged over the full 2011 data.

Measurement	$0.0 \leq \eta < 1.5$	$1.5 \leq \eta < 2.5$
$20 \leq p_T \leq 30$	0.9849 ± 0.0003	0.9774 ± 0.0007
$p_T > 30$	0.9928 ± 0.0001	0.9938 ± 0.0001

Table 2: The efficiency of the trailing leg requirement for the double electron trigger, averaged over the full 2011 data.

Measurement	$0.0 \leq \eta < 1.5$	$1.5 \leq \eta < 2.5$
$20 \leq p_T \leq 30$	0.9923 ± 0.0002	0.9953 ± 0.0003
$p_T > 30$	0.9948 ± 0.0001	0.9956 ± 0.0001

Table 3: The efficiency of the leading leg requirement for the double muon trigger, averaged over the full 2011 data.

Measurement	$0.0 \leq \eta < 0.8$	$0.8 \leq \eta < 1.2$	$1.2 \leq \eta < 2.1$	$2.1 \leq \eta < 2.4$
$20 \leq p_T \leq 30$	0.9648 ± 0.0007	0.9516 ± 0.0013	0.9480 ± 0.0009	0.8757 ± 0.0026
$p_T > 30$	0.9666 ± 0.0003	0.9521 ± 0.0005	0.9485 ± 0.0004	0.8772 ± 0.0012

Table 4: The efficiency of the trailing leg requirement for the double muon trigger, averaged over the full 2011 data.

Measurement	$0.0 \leq \eta < 0.8$	$0.8 \leq \eta < 1.2$	$1.2 \leq \eta < 2.1$	$2.1 \leq \eta < 2.4$
$20 \leq p_T \leq 30$	0.9655 ± 0.0007	0.9535 ± 0.0013	0.9558 ± 0.0009	0.9031 ± 0.0023
$p_T > 30$	0.9670 ± 0.0003	0.9537 ± 0.0005	0.9530 ± 0.0004	0.8992 ± 0.0011

▶ Electron selection

- ▶ $p_T > 20 \text{ GeV}; |\eta| < 2.5$
- ▶ VBTF90 (cuts tightened to match Calold+TrklVL HLT requirements)
- ▶ $d_0 \text{ (PV)} < 0.04 \text{ cm}, dz \text{ (PV)} < 1 \text{ cm}$
--calculated w.r.t. 1st good DA PV
- ▶ no muon $\Delta R < 0.1$
- ▶ ≤ 1 miss hits, $|\text{dist}| < 0.02 \text{ cm}$ and < 0.02 , CMS AN-2009-159
- ▶ Veto electrons with a supercluster in the transition region ($1.44 < |\eta| < 1.56$)
- ▶ $\text{iso}/p_T < 0.15$ (EB pedestal subtraction 1 GeV, no fastjet correction)
- ▶ $\text{ecaliso}/p_T < 0.2$

▶ Muon selection

- ▶ $p_T > 20 \text{ GeV}; |\eta| < 2.4$
- ▶ global and tracker muon
- ▶ $\chi^2/\text{ndf} < 10$
- ▶ $n\text{ValidHits} > 10$ -- to be updated to frac of validHits
- ▶ $\text{valid StandAloneHits} > 0$
- ▶ $d_0 \text{ (PV)} < 0.02 \text{ cm}, dz \text{ (PV)} < 1 \text{ cm}$
--calculated w.r.t. 1st good DA PV
- ▶ $(p_T)/p_T < 0.1$
- ▶ $\text{iso}/p_T < 0.15$ (no fastjet correction)

Sample	ee	$\mu\mu$	$e\mu$	all
ttdil	1535.60 ± 9.82	1813.86 ± 10.31	5747.85 ± 18.69	9097.31 ± 23.50
ttotr	39.74 ± 1.63	4.06 ± 0.46	93.09 ± 2.41	136.88 ± 2.94
wjets	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
DYee	16.85 ± 3.28	0.00 ± 0.00	0.00 ± 0.00	16.85 ± 3.28
DYmm	0.00 ± 0.00	22.96 ± 3.66	3.80 ± 1.60	26.76 ± 3.99
DYtautau	13.35 ± 2.92	6.59 ± 1.94	31.22 ± 4.21	51.16 ± 5.48
VV	8.27 ± 0.44	10.20 ± 0.47	27.90 ± 0.81	46.37 ± 1.03
tw	72.54 ± 2.11	86.77 ± 2.23	289.37 ± 4.20	448.68 ± 5.20
Total MC	1686.35 ± 11.10	1944.43 ± 11.35	6193.23 ± 19.84	9824.00 ± 25.41
Data	1631.00 ± 40.39	1964.00 ± 44.32	6229.00 ± 78.92	9824.00 ± 99.12

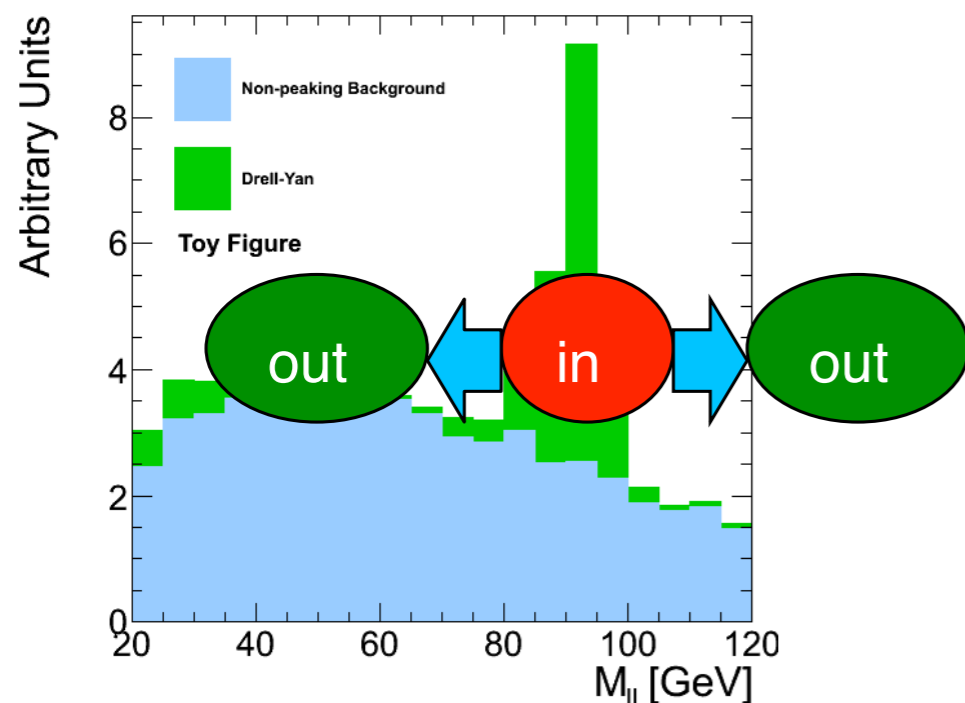
Uncertainties are statistical only

- ▶ MC events are weighted to match trigger efficiency, b tagging efficiency, and number of vertices distribution in data
- ▶ We use MC@NLO for the $t\bar{t}$ component
 - ▶ normalized so that total MC yield matches data
 - ▶ $t\bar{t} \rightarrow \ell^+ \ell^-$ contributes 92% of the total yield

- Estimate ee and $\mu\mu$ Drell-Yan using the method in [CMS AN-2009-023](#):

$R_{\text{out/in}}$ method

- Use data in Z peak to predict DY yields in the signal region by propagating via the MC ratio out/in-peak



$$N_{\text{out}}^{\ell\ell, \text{exp}} = R_{\text{out/in}}^{\ell\ell} \left(\underbrace{N_{\text{in}}^{\ell\ell}}_{\text{same-flavor events in Z peak}} - \underbrace{N_{\text{in}}^{\text{non-Z}}}_{\text{opposite-flavor events in Z peak}} \right)$$

Z-peak to signal region ratio from MC, verified in data

- Estimate (after event selection): 45.6 ± 6.8 (stat+syst) events
- consistent with MC prediction of 39.8 ± 4.9 events

- Estimate contribution from fake leptons using the data-driven tight-to-loose method described in CMS

AN-2010/257

- measure tight-to-loose fake rates as a function of lepton P_T and eta
- estimate number of fakes in data based on number of fakeable object (FOs). Weight each lepton+FO event by:
 - use MC to account for signal contamination in the FO sample
 - fake background primarily from $t\bar{t}$ decaying to lepton+jets

$$\epsilon_{\text{fake}}(p_T, \eta) = \frac{N_{\text{pass tight}}(p_T, \eta)}{N_{\text{loose}}(p_T, \eta)}$$

$$w_i = \frac{\epsilon_{\text{fake}}(p_{Ti}, \eta_i)}{1 - \epsilon_{\text{fake}}(p_{Ti}, \eta_i)}$$

- ▶ Estimate (after event selection): 237^{+294}_{-237} (stat+syst) events
- ▶ consistent with MC prediction 150 ± 8 events